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Formaldehyde in newly built dwellings

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SUMMARY
The motive for this study was the recent recognition of a carcinogenic effect on humans caused by formaldehyde. The purpose was to elucidate if the formaldehyde concentration in newly built Danish dwellings could cause health risks. The concentration of formaldehyde was measured in 20 new houses in Denmark. In addition temperature, humidity, CO_2 concentration and air change was measured. The measurements were made in the smallest room suitable for habitation in the dwelling. During measurements the windows and doors were closed and all other ventilation options were kept as the occupants had left them. Results showed that the newest and largest dwellings had a tendency to have the highest formaldehyde concentrations. No relation was found between concentration of formaldehyde and size of selected room, air change rate, ventilation principle, indoor temperature and humidity. Formaldehyde concentration exceeded the guiding value of 0.10 mg/m^3 stated by WHO in two dwellings.

KEYWORDS
Formaldehyde, Cancer, Irritation, Chipboard, Air quality

INTRODUCTION

Formaldehyde has been known as a major irritant in indoor air for many years. Its carcinogenic effects on humans (IARC, 2006) have recently been recognized and this has initiated a renewed interest in formaldehyde problems.

The purpose of the presented study was to elucidate if the formaldehyde concentration in newly built Danish dwellings could cause health risks.

Known sources of formaldehyde in indoor air comprise from wood-based panels (Brown, 1999) acid-cured cabinet and floor finishes (Kelly et al. 1999) as well as low-voc latex paint (Chang et al. 2002). Formaldehyde is also a constituent of tobacco smoke (IARC, 1986) and smoke from wood-burning fireplaces (Lipari et al. 1984).

Annual world production of formaldehyde is about 20 million ton and it is used mainly in the production of phenolic, urea, melamine and polyacetal resins that have uses as adhesives and binders in wood product, paper, and synthetic fiber products. Formaldehyde is used directly in aqueous solution (formalin) as a disinfectant and preservative in many applications.

Sensitive subjects may detect formaldehyde odor at concentrations as low as 0.03 mg/m^3 and concentration above 0.1 mg/m^3 may cause irritation in eyes and nose (WHO, 2000). These concentrations are more than an order of magnitude below cytotoxic damage to nasal mucosa and an indoor air quality guideline value of 0.1 mg/m^3 as a 30-minute average is recommended (WHO, 2000).

The current regulation in Denmark for formaldehyde emissions from wood-based construction products indicates that the indoor air concentration should not exceed 0.15 mg/m^3.

METHODS

The concentration of formaldehyde was measured in 20 new houses in Denmark in the period February to June 2007. All the houses were erected and occupied within the last six years prior to the measurements. The dwellings were chosen to represent houses with comprehensive use of wood based panels. None of the houses had very high use including panels in ceiling, walls and floor.

The measurements took place in the smallest room suitable for habitation in the dwelling. This room was also assumed to have the highest concentration of formaldehyde. The volume of the room was in average 27.8 m^3 ranging from 18.5 m^3 to 52.4 m^3. Measurements were performed with the houses in normal use. All windows and doors were closed during the measurements and all other ventilation options were left at the setting the had when the visit for performing the measurements started. No changes in furnishing were made in relation to the investigation.

Temperature was measured with a thermocouple connected to an instrument from H. Blichfeldt Electronic APS type Thermometer T301c No. 840622. Humidity, CO_2 concentration and concentration of tracer gas for air change assessment were measured by infrared spectrometry using the gas analyzer type 1312 from INNOVA as.

Air change was calculated based on the decay of tracer gas after it had been dosed. During the decay air was mixed by operating two desk fans in the room. The door to the rest of the dwelling was closed but air change may have included some transfer air from adjacent rooms through cracks.

Formaldehyde was sampled on DNPH tubes (C18 polymer coated with 2,4-dinitrophenylhydrazin). During 30 minutes of sampling the flow was adjusted to 1 l/min using pumps type SKC.

The tubes were analyzed by HPLC liquid chromatography by UV detection according to ISO 16000-3, Indoor air – Part 3. Detection limit was approximately 0.03 µg/tube equivalent to approximately 1 $\mu g/m^3$. Uncertainty was in general 15 % of the reported values.

Based on an interview with the house owners a registration was made of erection year, house area, dwelling area, inner area of room selected for measurements, ventilation principle and smoking habits among occupants.

RESULTS

The air change rate measurements had an average value of 0.44 h^{-1} (std. dev. 0.26 h^{-1}). Numbers of dwellings within some intervals for air change rate from 0 to 1 air changes per hour are shown in Figure 1.

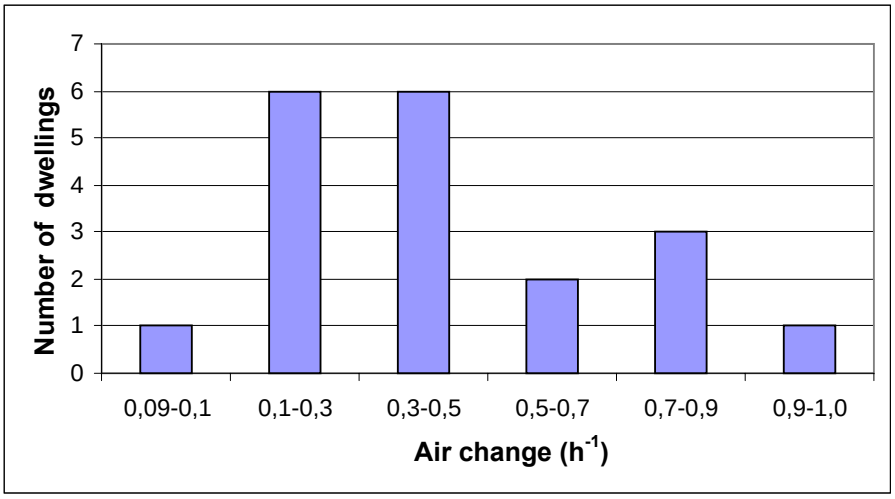

Figure 1. The number of dwellings in six intervals for air change rate.

Formaldehyde concentrations were in average 0.050 mg/m^3 (std. dev. 0.026 mg/m^3). Concentrations are shown in relation to number of dwellings in Figure 2.

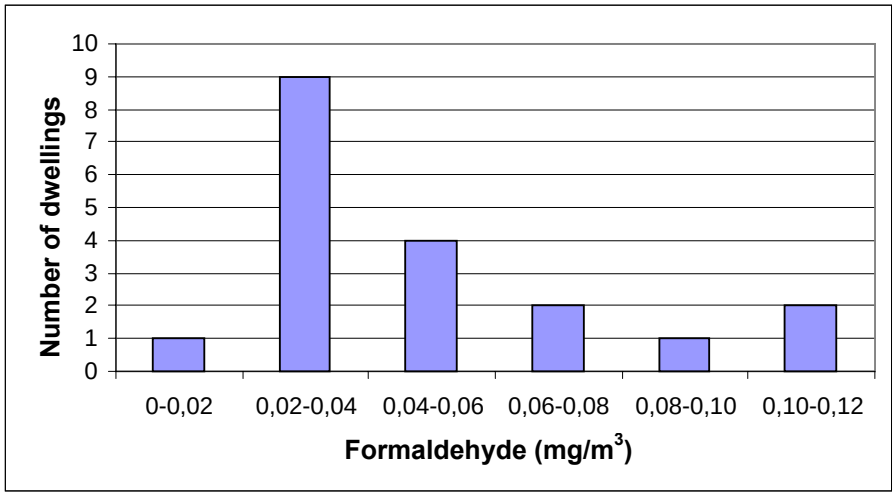

Figure 2. The number of dwellings in six intervals for formaldehyde concentration.

Carbon dioxide (CO_2) is found in outdoor air at concentrations between 350 and 450 ppm. Concentrations in indoor air are normally higher mainly because CO_2 is a major human metabolite and it is also produced in combustion processes. In indoor air it is often used as an indicator of human occupancy in relation to outdoor air supply. Numbers of dwellings within some intervals for CO_2 concentration are shown in Figure 3.

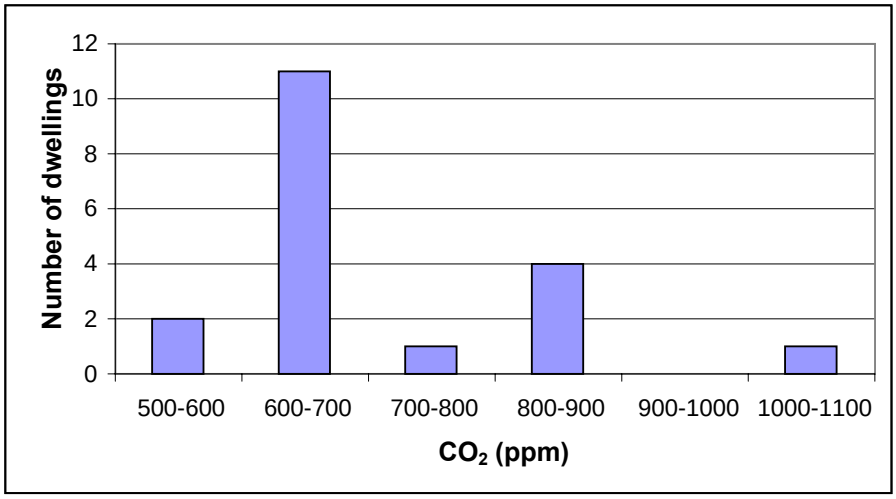

Figure 3. The number of dwellings in six intervals for CO_2 concentration.

Figure 3 shows rather limited CO_2 concentrations reflecting that only few occupants were present in the dwellings in the middle of the day at the time of the measurements.

Elevated moisture content can be an indication of human presence but moisture may also come from laundry, bathing and cooking activities. In some of the dwellings drying of laundry took place in the measurement room or other adjacent rooms. This is reflected in Figure 4 showing moisture content in relation to number of dwellings.

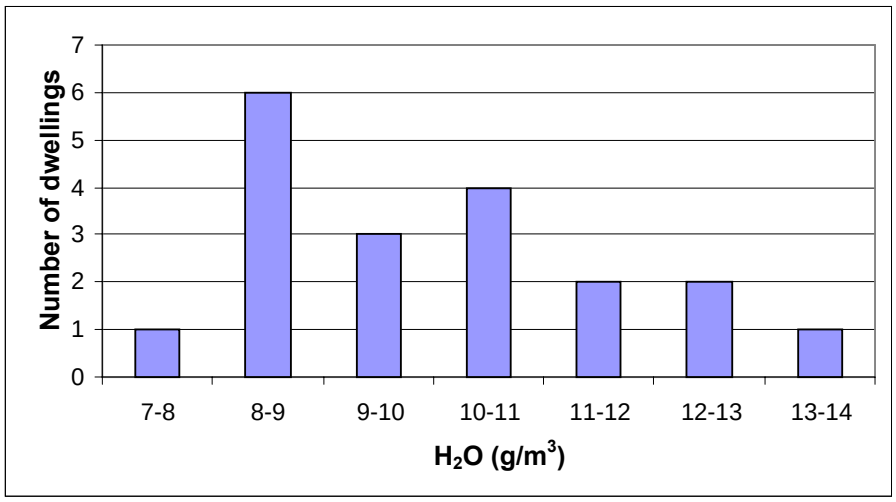

Figure 4. The number of dwellings in seven intervals for moisture content in indoor air.

Smoking of tobacco is a well known source of formaldehyde in indoor air. Smoking did not take place in any of the dwellings during measurements. The information received from house owners concerning smoking habits in their homes has been the basis for Figure 5. This figure shows average formaldehyde concentration and standard deviation of individual measurements in relation to smoking habits in the dwellings. Average concentration was slightly higher in homes without smoking. This finding is obviously not significant.

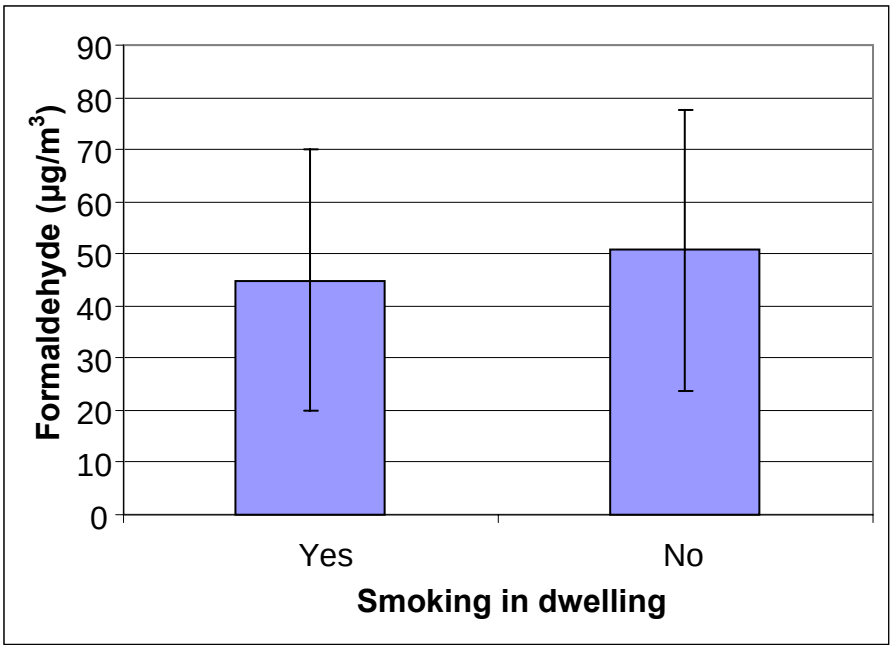

Figure 5. Average concentration of formaldehyde and standard deviation in relation to smoking habits in the dwellings.

As demonstrated in Figure 6 and 7 results showed that the newest and largest homes had a tendency to have the highest formaldehyde concentrations.

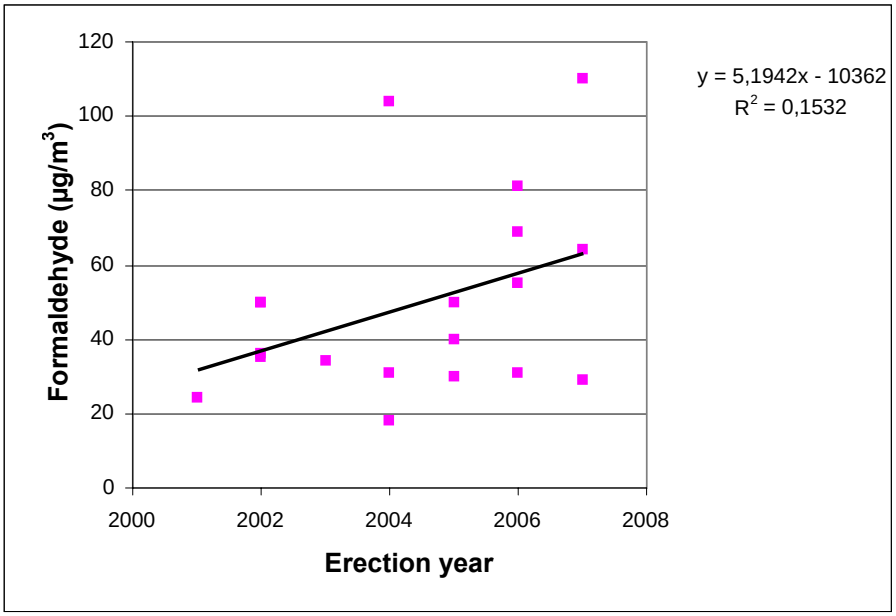

Figure 6. Relation between erection year and formaldehyde concentration.

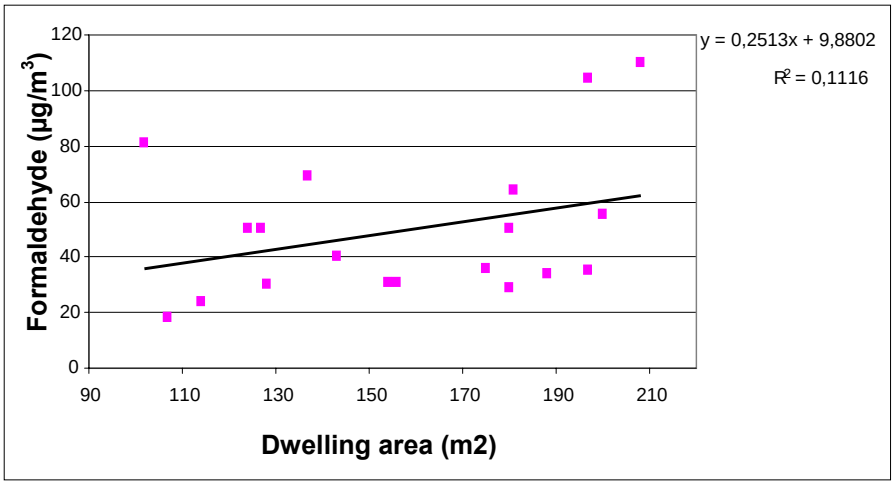

Figure 7. Relation between dwelling area and formaldehyde concentration.

No relation between concentration of formaldehyde and size of selected room, air change rate, ventilation principle, indoor temperature and humidity was found. Smoking among occupants was also not significant for formaldehyde concentration in the selected room. Formaldehyde concentration exceeded the guiding value of 0.10 mg/m^3 stated by WHO for the highest permissible mean value at 30 minutes measurements in two dwellings.

DISCUSSION

Measurements show that average air change rates of 0.44 h^{-1} were somewhat below 0.5 h^{-1} that is required by the building regulative in Denmark for both individual rooms and in the dwelling as a whole. 68 % of the dwellings had less than 0.5 air changes per hour.

Dwellings where occupants allowed smoking had a marginal lower concentration of formaldehyde than the others. However no active smoking took place during the measurements This was probably a chance observation and it was far from significant.. The highest concentrations were not found in dwellings with occasional smoking. The rather high concentrations found in this study are not caused by smoking.

Regression analysis only showed significant relations between formaldehyde concentration and total dwelling area and erection year.

Measurements in two dwellings showed formaldehyde concentrations exceeding the WHO recommendation of 0.1 mg/m3. They were 0.104 mg/m^3 and 0.110 mg/m^3.

The highest concentrations are exceeding limits for odor detection and irritation in eyes and nose among sensitive persons but the concentrations are approximately an order of magnitude below the limit for cytotoxic damage to nasal mucosa. Therefore the concentrations are not expected to increase the risk for nose and nasopharyngeal cancer.

It was not possible to identify the sources of the high formaldehyde concentrations. The houses did not have comprehensive use of chipboard or other known sources of formaldehyde. Furniture, flooring, insulation, paint and other surface coverings may be suspected. Furthermore cleaning and surface maintenance products such as floor finishes may also be suspected of being significant formaldehyde sources.

Because of this uncertainty concerning which sources are important for formaldehyde concentration in indoor air in dwellings it is not possible to give directions on which products to avoid for reducing this exposure. Well established advice on increasing air change rates and keeping wooden products dry may limit the formaldehyde problems (Salthammer et al. 1995).

Sources may be identified by climate chamber experiments with a range of suspected construction and maintenance products as well as furniture.

CONCLUSIONS

- Concentrations up to 0.11 mg/m3 have been measured. This exceeds WHO recommendations.
- Concentrations may cause odor and irritation in eyes and nose but they are not expected to cause more serious health problems.
- Newest and biggest houses had a significant tendency to have the highest formaldehyde concentrations.
- Highest formaldehyde concentrations in this study were not found in dwellings where smoking was permitted.
- No significant relation was found between formaldehyde concentration and size of measurement rooms, air change rates, temperature and moisture content.
- There is a need for more research in order to identify the most important sources of formaldehyde in indoor air. Consumer products, construction products and furniture are suspected to contribute to formaldehyde concentrations in indoor air.

ACKNOWLEDGEMENT

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REFERENCES

Brown, S.K., 1999. Chamber assessment of formaldehyde and VOC emissions from wood-based panels. Indoor Air 9, 209-215.

Chang, J.C.S., Guo, Z., Fortmann, R., Lao, H.C., 2002. Characterization and reduction of formaldehyde emissions from a low-VOC latex paint. Indoor Air 12, 10-16.

IARC, 1986. Tobacco smoking. IARC Monographs on the Evaluation of the Carinogenic Risk of Chemicals to Humans, vol. 38, pp. 35-394.

IARC. 2006. Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol. IARC Monographs Vol 88. IARC

Kelly, T.J., Smith, D.L., Satola, J., 1999. Emission rates of formaldehyde from material and consumer products found in California homes. Environ. Sci. Technol. 33, 81-88.

Lipari, F., Dasch, J.M., Scruggs, W.F., 1984. Aldehyde emissions from wood-burning fireplaces. Environ. Sci. Technol. 18, 326-330.

Salthammer, T, Fuhrmann, F, Kaufhold, S, Meyer, B and Schwarz, A. 1995. Effects of Climatic Parameters on Formaldehyde Concentrations in Indoor Air. Indoor Air 5:120-128.

WHO. 2000. Air Quality Guidelines for Europe, Second Edition. Regional Publications, European Series, No. 91, World Health Organization. Regional Office for Europe. Copenhagen.